COMPARING MULTIBODY SUBJECT KINEMATICS AND DYNAMICS ON DIFFERENT GAIT MODES

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Introduction

As a result of injury or pathology, subjects frequently adopt altered gait modes [1] such as stiff knee gait (SKG) at lower velocities or slow running (SR) for higher velocities, due to inability to perform normal gait (NG) or to protect physical integrity, although the kinematic and dynamic effects of adopting these alternative gait modes are not clear. The purpose of this study is to gain insight on kinematics and dynamics of a specific subject lower limb segments during NG, STG and SR by comparing selected parameters in order to point possible reasons to adopt alternative gait modes based on detected differences.

Methods

Musculoskeletal analysis [2] was performed using AnyGait v.0.92 for multibody inverse kinematics and dynamics of one male subject (70 kg mass and 1.86 m height) during NG, SKG and SR. Data was obtained from simultaneous recordings of ground reaction forces with two AMTI force plates at 2000 Hz and skin markers at right and left anterior superior iliac spines, thigh superior, knee medial and lateral, shank superior, ankle medial, lateral and toes recorded with 8 camera Qualisys system at 100 Hz. Stick figure model was morphed with Twente Lower Extremity Model (TLEM) to match size and joint morphology. Inverse kinematics was performed to obtain joint angles and dynamic analysis based on joint angles and kinetic boundary conditions.

Results

	NG	SKG	SR
HJ F (N)	4400	3600	6500
KJ F (N)	4250	4500	11800
GR F (N)	900	820	1750
HJ M (Nm)	78	75	50
KJ M (Nm)	30	30	40
AJ M (Nm)	15	15	0
HJ θ (rad)	0.65	0.70	0.62
KJ θ (rad)	1.06	0.70	0.69
AJ θ (rad)	0.40	0.45	0.60
HJ ω (rad/s)	3.5	2.9	5.0
KJ ω (rad/s)	6.0	4.6	7.5
AJ ω (rad/s)	2.9	2.5	6.9
HJ α (rad/s^2)	46	39	46
KJ α (rad/s^2)	120	52	147
AJ α (rad/s^2)	140	84	119

Table 1: Maximum values of selected parameters.

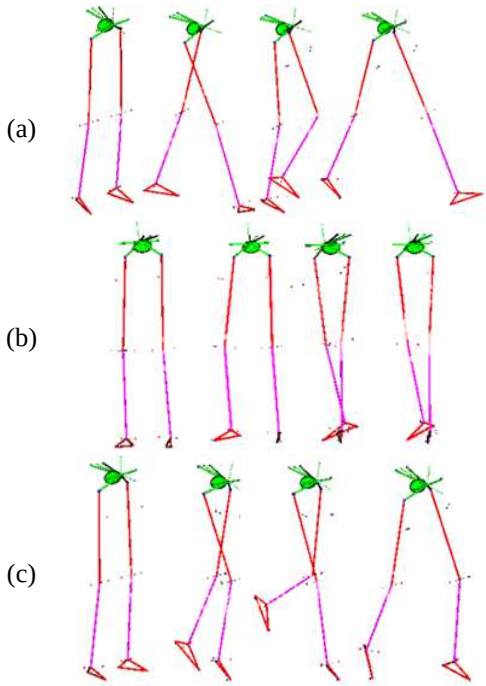

Figure 1: Stick figures of normal gait (a), stiff knee gait (b) and slow running (c).

Discussion

SKG results in lower maximum ground reaction force (GR F) and hip joint force (HJ F) when compared to NG and SR, with higher knee joint force (KJ F) at SKG than NG. Nevertheless, hip, knee and ankle joint present similar maximum force moments (HJ M, KJ M and AJ M) at SKG and NG, with higher values at HJ, AJ and lower values at KJ when compared to SR. These values are associated with higher amplitudes of hip joint angles (HJ θ) at SKG than NG and SR, with lower KJ θ at SKG and SR than at NG. Also SKG presents lower maximum values of angular velocity ω and acceleration α at all joints than at NG and SR, pointing SKG as an adaptation to difficulty in NG and SR.

References

1. Minetti et al, J Theor Biol, 186:467-476, 1997.
2. Erdemir et al, Clin Biomech, 22:131-154, 2007.

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